ORIGINAL DESIGN CONCEPT

(1) INFORMATION SIGNAL BAND - WIDTH FROM 300 Hz TO 3.4 kHz, WHICH IS IDENTICAL TO THE CONVENTIONAL TELEPHONE BAND - WIDTH

(2) TRANSMISSION AND RECEPTION OF DIGITAL AS WELL AS ANALOG SIGNALS WITH HIGH TRANSPARENCY

(3) SEAMLESS INTERFACE WITH SIGNALS COMING FROM CONVENTIONAL TELEPHONE LINES WITHOUT ANY ADDITIONAL EQUIPMENT

NTT

BREAKTHROUGHS IN SINGLE SIDE - BAND TECHNOLOGY

(1) REAL ZERO (RZ) DE - MODULATION

- DEMODULATE INFORMATION SIGNAL FROM ZERO - CROSSING POINTS OF RZ SSB SIGNAL
  (THIS WAS MATHEMATICALLY STUDIED BY B.F.LOGAN FROM BELL LABS; BSTJ, 56, 4, P.487, 977)

(2) ANTI - FADING TECHNOLOGY EFFECTIVE FOR DIGITAL AS WELL AS ANALOG SIGNALS

- TWO - BRANCH EQUAL GAIN COMBINING DIVERSITY RECEPTION
- RANDOM FM NOISE CANCELLER

NTT

LOGAN'S PAPER

THE BELL SYSTEM
TECHNICAL JOURNAL

DEVOTED TO THE SCIENTIFIC AND ENGINEERING
ASPECTS OF ELECTRICAL COMMUNICATION

Volume 56 April 1977 Number 4

Information in the Zero Crossings of Bandpass Signals

By B. F. LOGAN, JR.

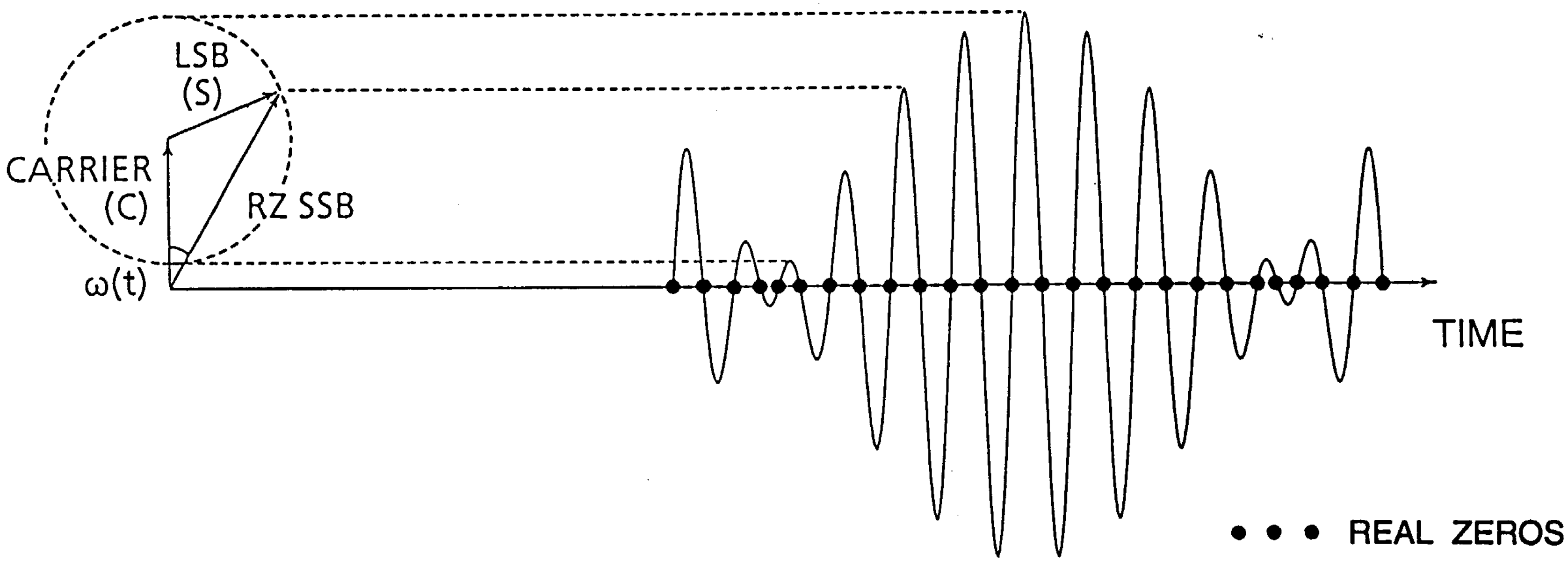
(Manuscript received October 4, 1976)

An interesting subclass of bandpass signals $\{h\}$ *is described wherein the zero crossings of h determine h within a multiplicative constant. The members may have complex zeros, but it is necessary that h should have no zeros in common with its Hilbert transform* $\hat{h}$ *other than real simple zeros. It is then sufficient that the band be less than an octave in width. The subclass is shown to include full-carrier upper-sideband signals (of less than an octave bandwidth). Also it is shown that full-carrier lower-sideband signals have only real simple zeros (for any ratio of upper and lower frequencies) and, hence, are readily identified by their zero crossings. However, under the most general conditions for uniqueness, the problem of actually recovering h from its sign changes appears to be very difficult and impractical.*

I. INTRODUCTION

Voelcker and Requicha[1] raised the question, among others, as to when a bandpass signal $h(t)$ might be recovered (within a multiplicative constant) from sgn $[h(t)]$, that is, from its zero crossings. There are really two questions here that should be treated separately: the question of uniqueness and the question of recoverability. Recoverability implies that there is an effective (stable) way of recovering the signal from the data. Uniqueness does not always imply recoverability. For example,

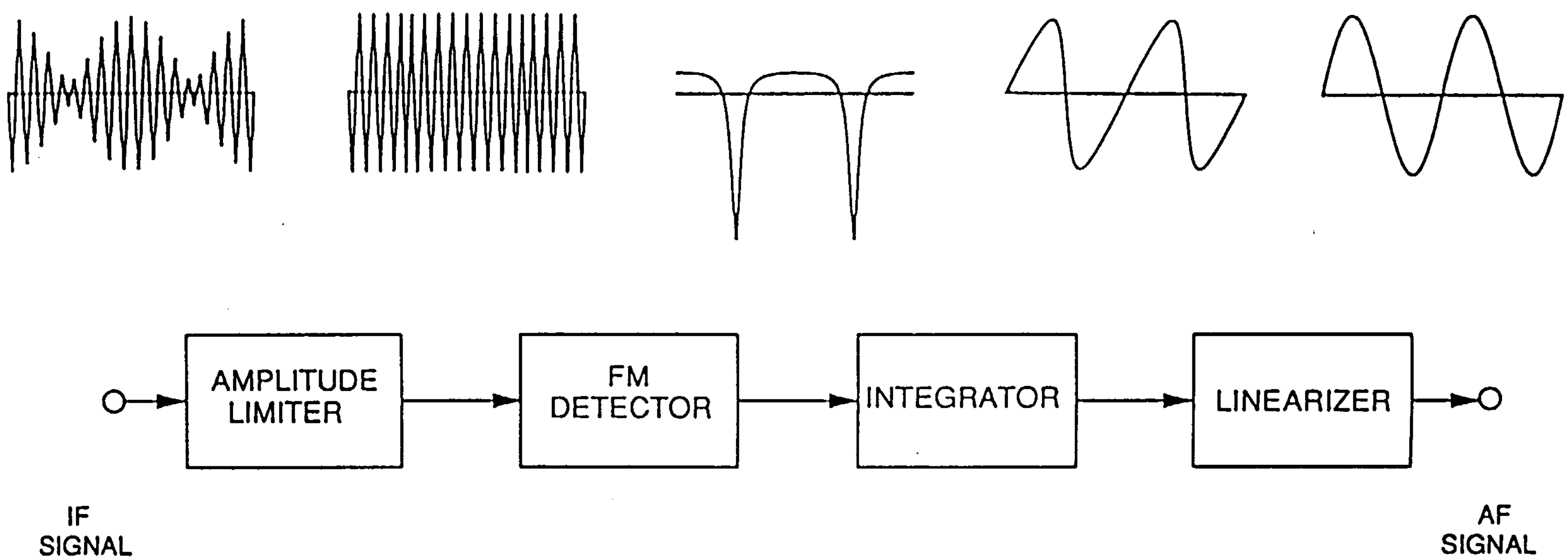
RZ SSB SIGNAL



$|C| > |S|$: RZ SSB CONDITION

NTT

BASIC CONFIGURATION OF RECEIVER



NTT

ANTI - FADING TECHNOLOGY

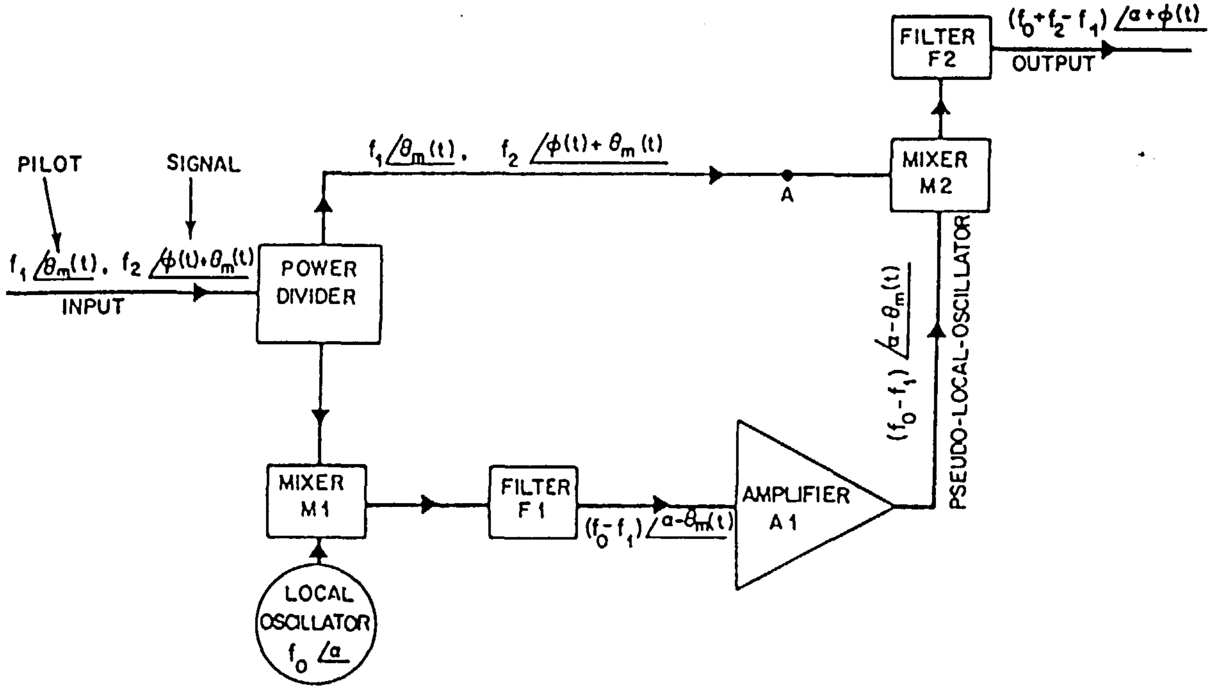


Figure 6.3-9 Block diagram of the phase correction circuit of one element of a coherent combiner using a pilot.

REPRINTED FROM WILLIAM C. JAKES, "MICROWAVE MOBILE COMMUNICATIONS", IEEE PRESS

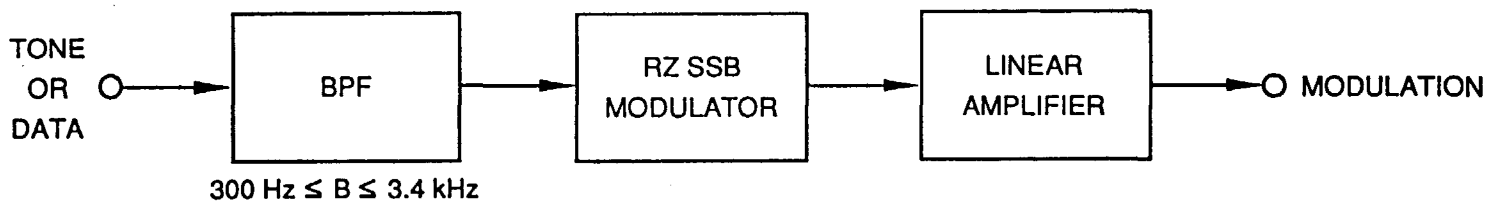
NTT

ILLUSTRATIVE APPLICATIONS

(1) ANALOG VOICE	:	NATURAL SOUND
	:	GRACEFUL DEGRADATION
(2) DIGITAL VOICE	:	CLEAR BUT ARTIFICIAL SOUND
	:	ABRUPT SILENCE BELOW BER THRESHOLD
	:	SUPPORTS DIFFERENT CODECS SUCH AS VOCODER, VSELP, PSI - CELP, ETC.
(3) GROUP 3 FACSIMILE	:	UP TO 9.6 kbps
	:	DIRECT INTERCONNECTION
	:	PREVALENT IN U.S. (9.2 million)
(4) DIGITAL DATA	:	UP TO 19.2 kbps USING VOICE - BAND MODEM EVEN IN FADING

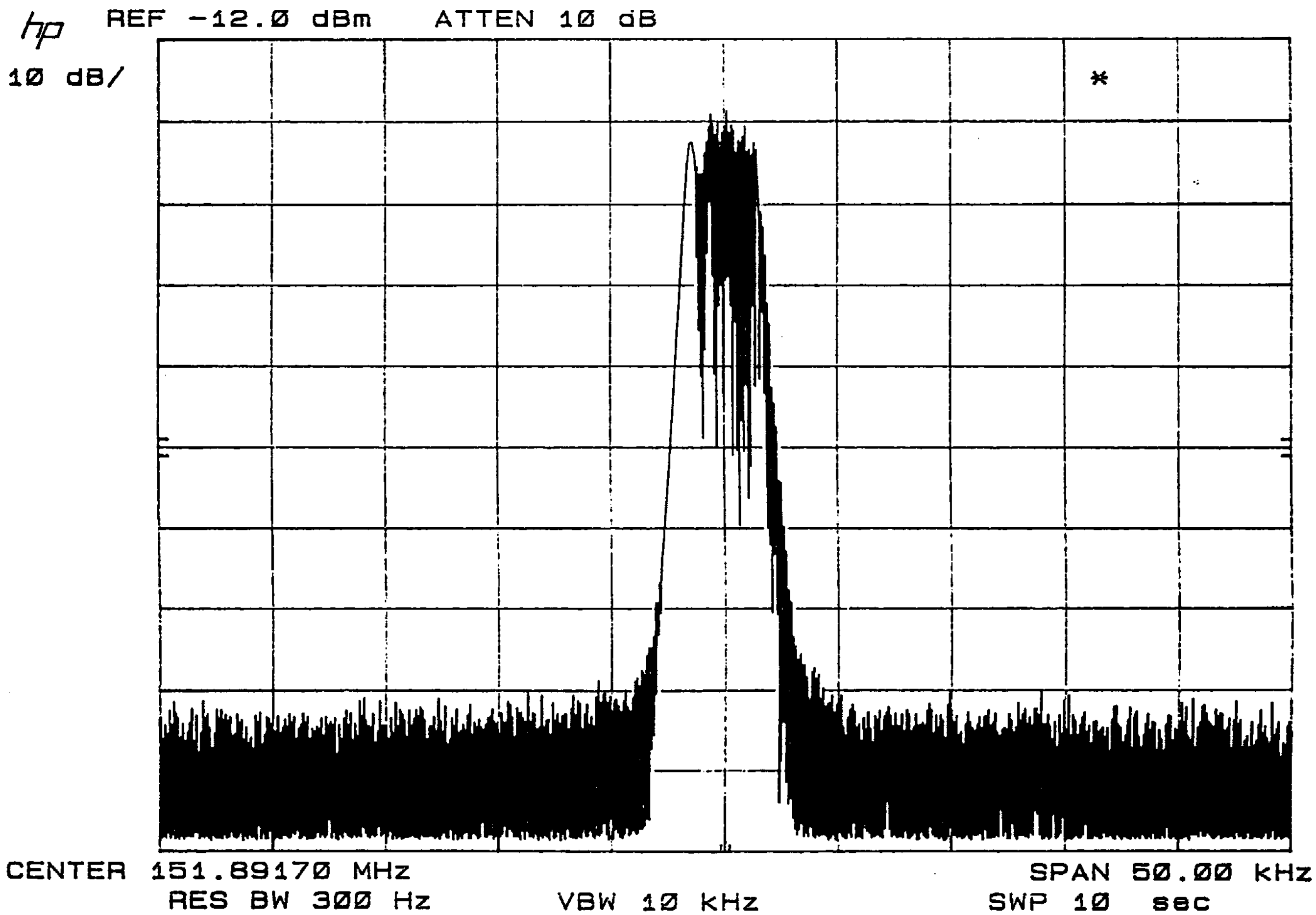
NTT

RZ SSB TRANSMITTER



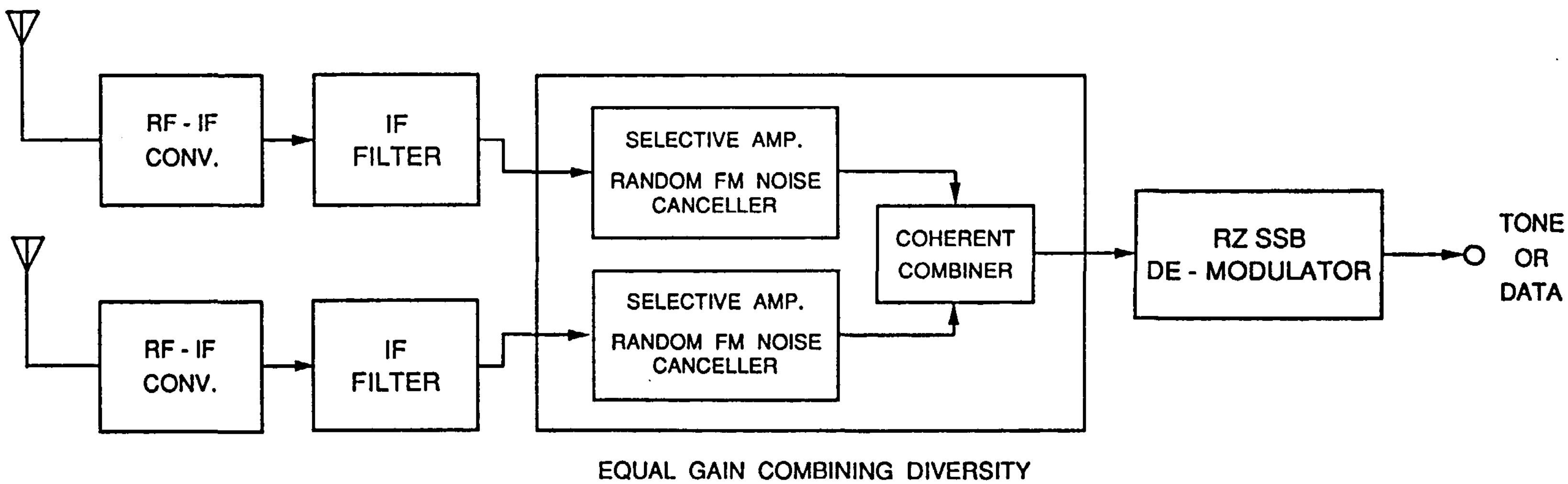
NTT

RZ SSB SPECTRUM MODULATED BY 16-QAM WITH 9.6 kbps



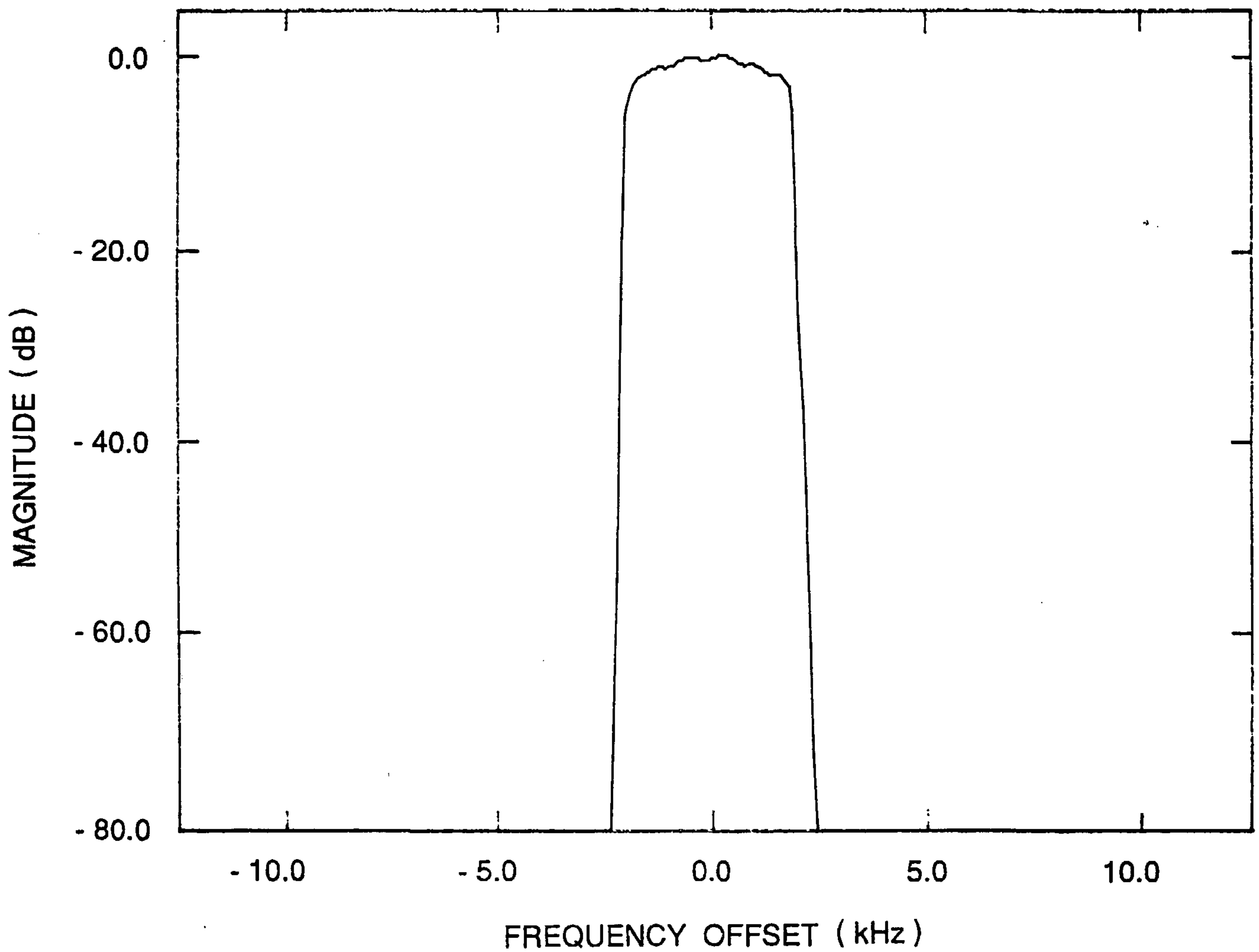
NTT

RZ SSB RECEIVER



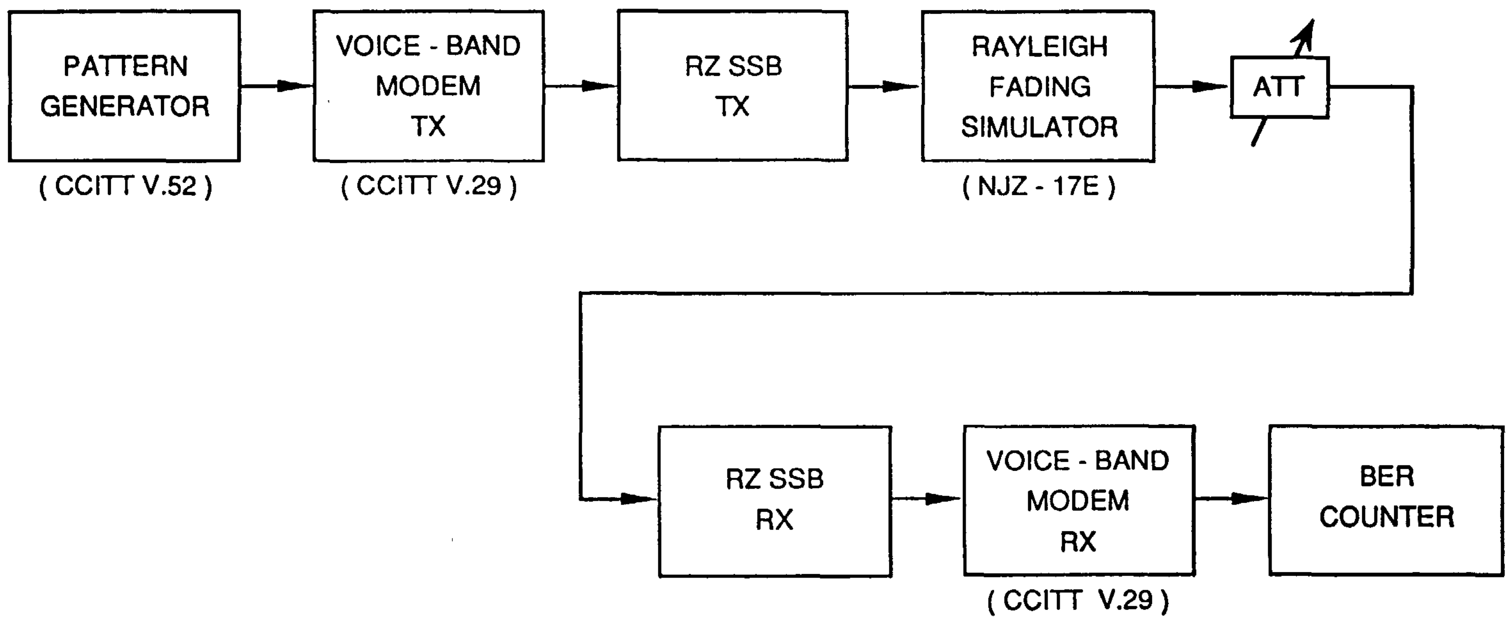
NTT

MEASURED IF FILTER RESPONSE

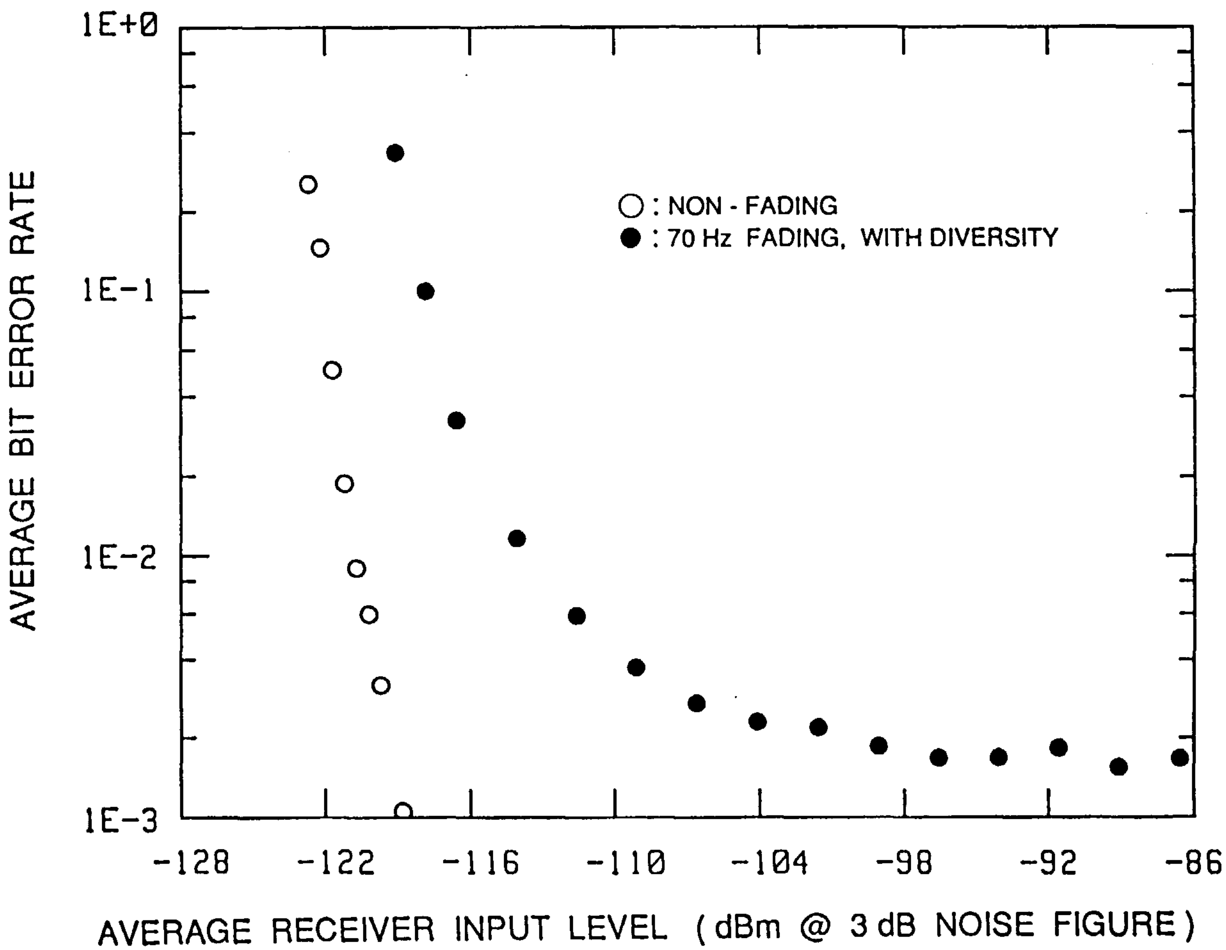


NTT

BER MEASUREMENT EXPERIMENTAL SETUP

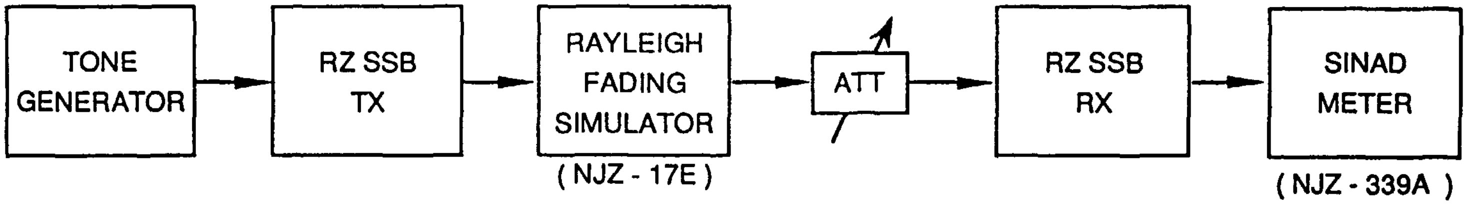


AVERAGE BER FOR 9.6 kbps DATA



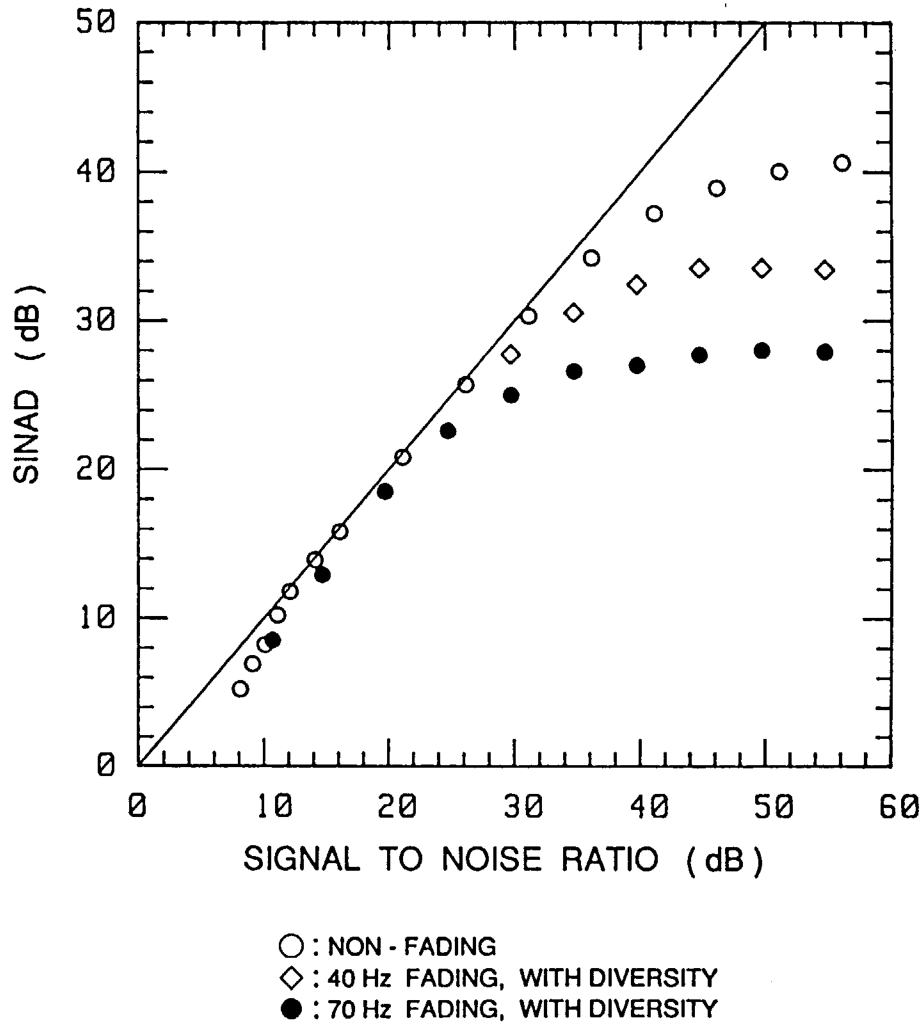
NTT

SINAD MEASUREMENT EXPERIMENTAL SETUP



NTT

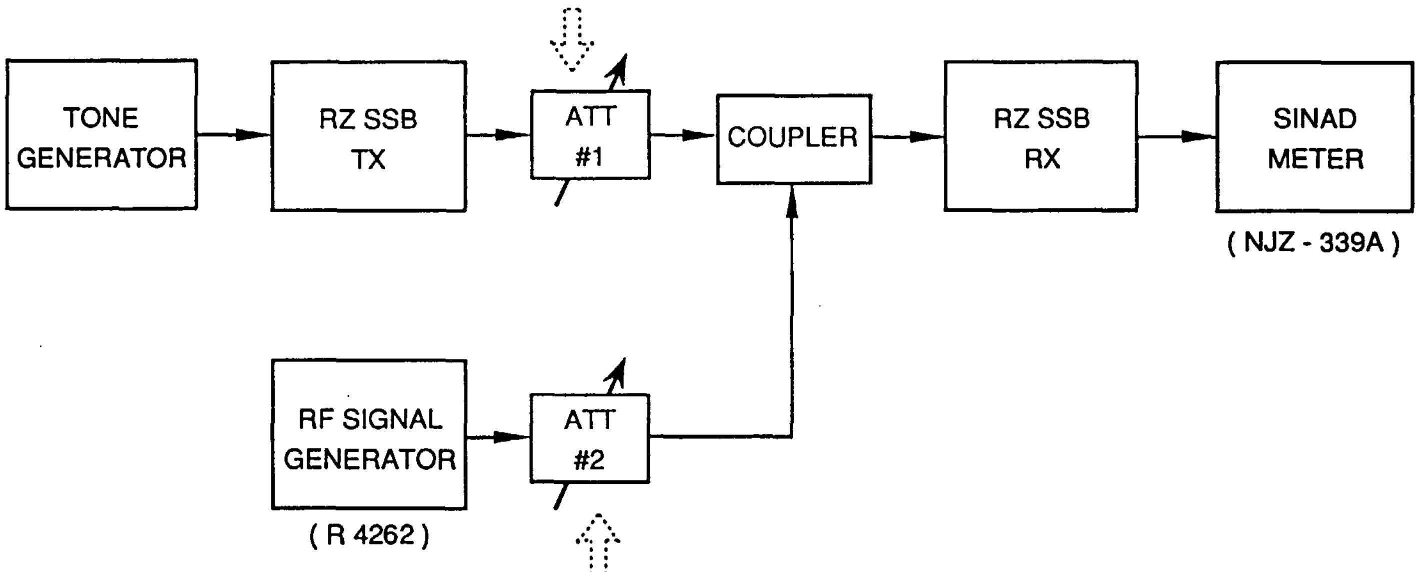
SINAD VS. SIGNAL TO NOISE RATIO



NTT

SELECTIVITY MEASUREMENT EXPERIMENTAL SETUP

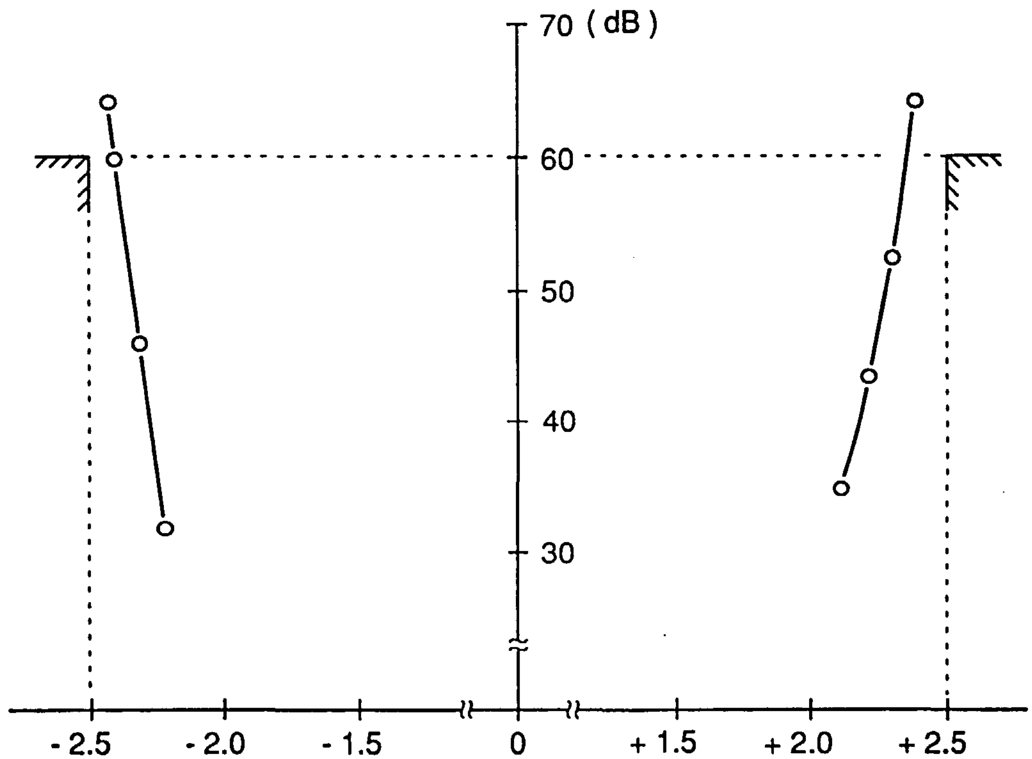
*1. SET LEVEL FOR **12 dB** SINAD WITH NO INTERFERENCE - NOTE LEVEL*
*2. INCREASE LEVEL BY **3 dB***



*3. APPLY LEVEL OF INTERFERENCE UNTIL **12 dB** SINAD IS REACHED AGAIN*
IEC STANDARD (PUBLICATION 489 - 5, 1987)

NTT

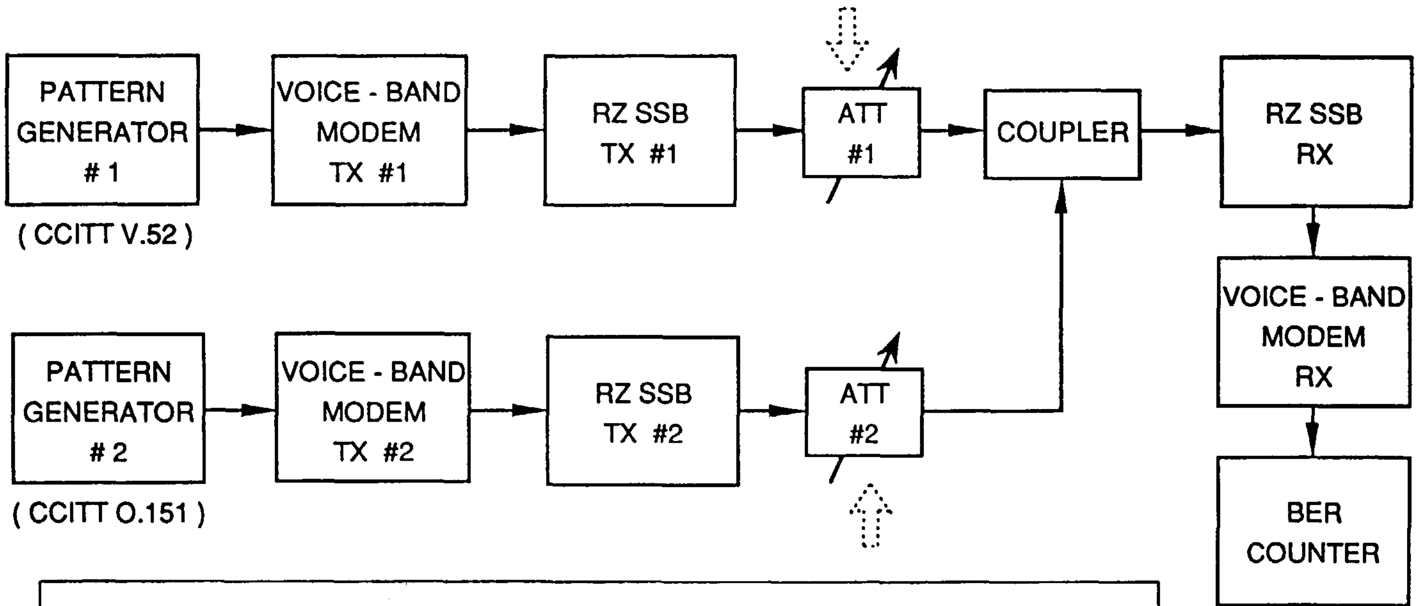
SELECTIVITY MEASURED BY TONE SIGNAL



NTT

COCHANNEL INTERFERENCE PROTECTION RATIO MEASUREMENT EXPERIMENTAL SETUP - RADIO SYSTEM

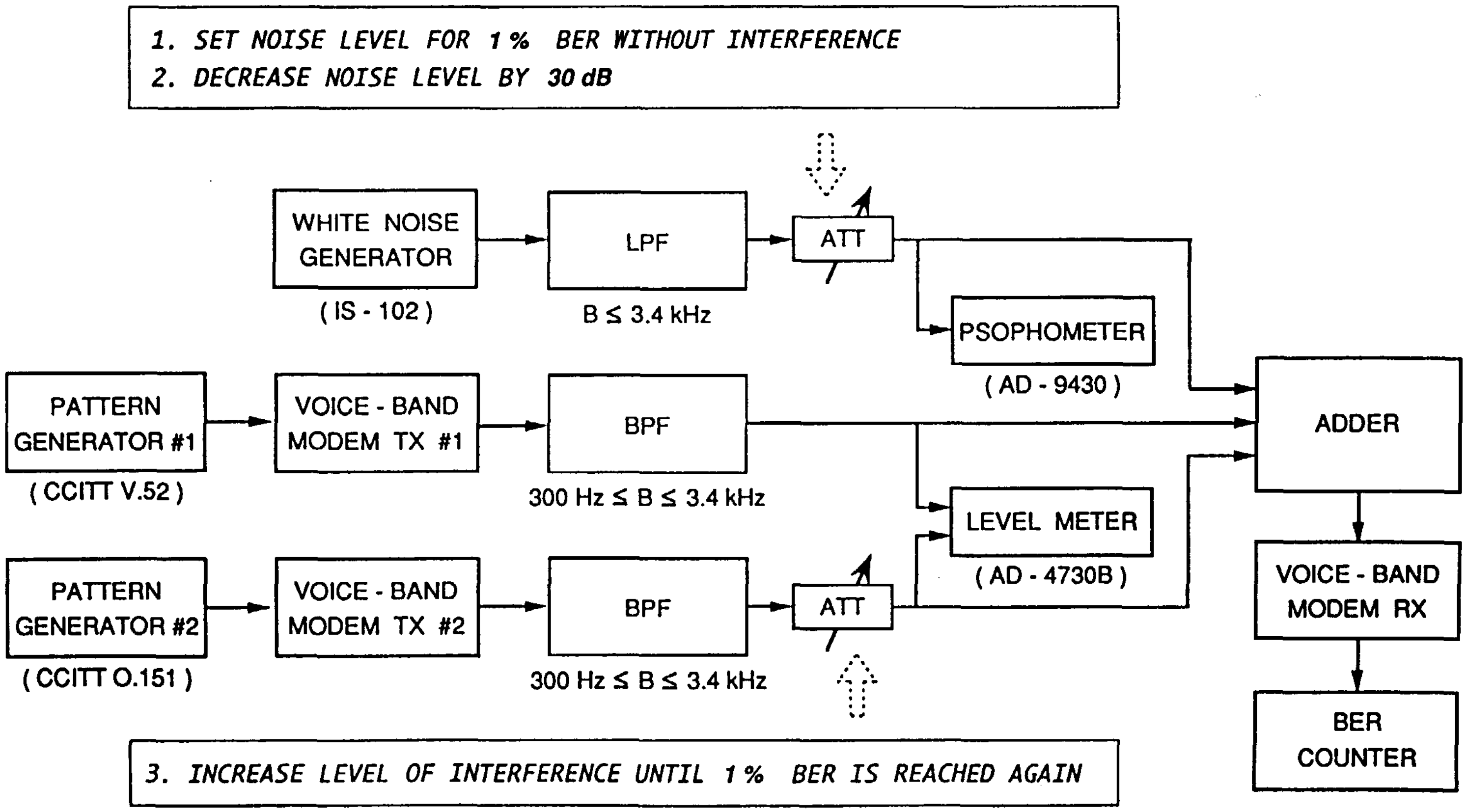
1. SET LEVEL FOR 1 % BER WITH NO INTERFERENCE - NOTE LEVEL
2. INCREASE LEVEL BY 30 dB



3. INCREASE LEVEL OF INTERFERENCE UNTIL 1 % BER IS REACHED AGAIN
RCR STANDARD (RCR STD - 27B)

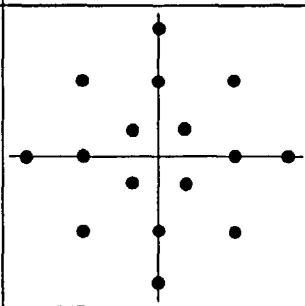
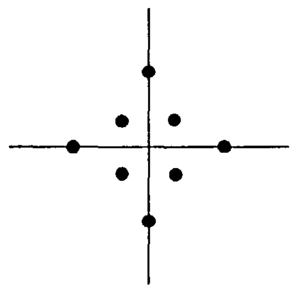
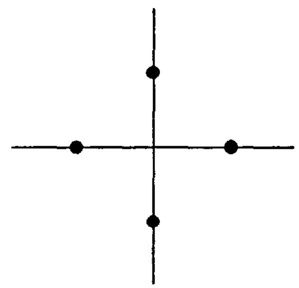
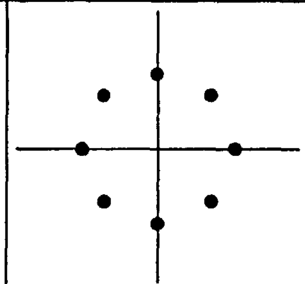
NTT

COCHANNEL INTERFERENCE PROTECTION RATIO MEASUREMENT EXPERIMENTAL SETUP - WIRED SYSTEM



NTT

COCHANNEL INTERFERENCE PROTECTION RATIO AND SIGNAL TO NOISE RATIO FOR VARIOUS VOICE - BAND MODEM SIGNALS

BIT RATE (kbps)		9.6	7.2	4.8	
MODULATION METHOD		16 - QAM	8 - QAM	4 - QAM	8 - PSK
SIGNAL CONSTELLATION					
CIPR FOR 1 % BER (dB)	RADIO	17.7	14.7	10.3	14.5
	WIRE	16.8	13.2	9.1	14.8
SNR FOR 1 % BER (dB)	RADIO	17.4	14.2	10.2	13.8
	WIRE	16.4	13.1	9.1	13.5

KEY DESIGN ISSUES WITH NARROW BAND RADIOS

PROBLEM		SOLUTION
(1) AMPLIFIER LINEARITY	:	CARTESIAN FEEDBACK PA
(2) FREQUENCY STABILITY	:	DIGITAL TCXO

NTT

VOICE CODERS FOR JAPANESE DIGITAL CELLULAR SYSTEM

(1) FULL - RATE CODER : 11.2 kbps VSELP

- DEVELOPED BY MOTOROLA

- 11.2 kbps = 6.7 kbps (SPEECH CODING) + 4.5 kbps (ERROR PROTECTION)

(2) HALF - RATE CODER : 5.6 kbps PSI - CELP

- DEVELOPED BY NTT

  (KAZUNORI MANO et al., " DESIGN OF A PSI - CELP CODER FOR MOBILE COMMUNICATIONS ", PROC. IEEE WORKSHOP ON SPEECH CODING FOR TELECOMMUNICATIONS, PP.21 - 22, OCT. 13 - 15, 1993)

- 5.6 kbps = 3.45 kbps (SPEECH CODING) + 2.15 kbps (ERROR PROTECTION)

NTT

SPEECH QUALITY COMPARISON BETWEEN VSELP AND PSI - CELP

GROUP 1

1. ORIGINAL SPEECH
2. VSELP UNDER BER = 0 %
3. PSI - CELP UNDER BER = 0 %

GROUP 2

4. VSELP UNDER BER = 1 %
5. PSI - CELP UNDER BER = 1 %

GROUP 3

6. VSELP UNDER BER = 3 %
7. PSI - CELP UNDER BER = 3 %

NTT

SUMMARY OF RZ SSB TECHNOLOGY

(1) EXTREMELY SPECTRUM EFFICIENT

(2) WIDE RANGE OF APPLICATIONS

(3) TRANSPARENT CHANNEL EVEN IN FADING

(4) FIELD - TESTED TECHNOLOGY

(5) ALL NECESSARY DEVICES EXIST

(6) COST COMPARABLE TO EXISTING SYSTEMS

(7) APPLICABLE TO PORTABLE UNIT

(8) APPLICABLE TO TIME DIVISION DUPLEXING (TDD) SYSTEM, ALLOWING DUPLEX OPERATION IN A SINGLE CHANNEL

NTT